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**INTERNAL INVENTION DISCLOSURE**

Send To:

IID No..

02-018

A. Identify names and addresses of inventors:  
Jose John Vennat  
Wood Group ESP, Inc.  
5500 SE 59<sup>th</sup> Street, OK 73135

B. Subject of invention: Mult-stage Turbomachines for handling Two Phase Fluids

C. When did you first think of this invention? 1997

D. What records do you have to substantiate this conception date?  
No official records except I have verbally mentioned about Multiphase Pump during the job interview to join WGESP.

E. To whom did you first disclose this invention?  
Jeff Dwiggins during Engineering Staff Meeting.

F. On what date did you make the disclosure of E above?  
1998.

G. When did you first do any work toward carrying out the invention?  
12/13/1999

H. Who has observed the progress of your work?  
Steve Breit

I. Are there other IIDs now on file or contemplated, yours or others, that relate in any way to this invention? Any pertinent literature or patent references? Give details.

J. Has the invention been used or tested in any manner? Yes [ ] No [X ]  
When and Where?  
Has there been any subsequent use or testing? Give details.

K. Are there any plans for use? Yes [X ] No [ ]  
Give details. Currently working on a project for making a prototype of the subject invention by third quarter of 2003.

L. Give dates and details regarding any samples, sales, information, or publications relating to this invention which have been or will be given to others.  
Have included a slide on Electrical Submersible Multiphase Pump project in pump presentations to Customers of WGESP since 1999.

M. If put into use (K above) or samples, information, or publication (L above) takes place in the future and prior to patent application, notify:

N. May be subject to Government Contract Yes [ ] No [ X ]

The following should be entered on the attached blank sheet (use additional sheets if necessary). Be sure to sign and date all sheets and have them witnessed. Witnesses must be \_\_\_\_\_ employees, other than the named inventors, who understand the invention.

O. State precisely what your invention is, what problem was solved it. State how your invention differs from the known art and list the advantages of your invention. (Following Sheets - Do not write on back of sheets).

P. Provide illustrative experimental or operational data (if available) on your invention and include photographs, sketches, flow sheets, or other drawings where appropriate. Also provide, where possible, information as to materials employed, operating conditions, uses, etc., of your invention, both broadly and specifically. (Following Sheets - Do not write on back of sheets).

*John Vennat* (C. Jose John Vennat) 10/10/2002  
Inventor's Signature Date Signed

Witnesses:

I have examined and fully understand the attached description.

Inventor's Signature Date Signed

Inventor's Signature Date Signed

Inventor's Signature Date Signed

*Michael Lee* 10/10/02  
Witness' Signature Date Signed Date of first disclosure to me How Disclosed

*MTyagi* 10/10/02  
Witness' Signature Date Signed Date of first disclosure to me How Disclosed

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**CONFIDENTIAL****INTERNAL INVENTION DISCLOSURE**

Send To:

IID No.

02-018**Subject:Multi-Stage Turbomachines for handling Two Phase Fluids.**

Description of Invention: State the purpose or objects of the invention, its difference from what is known or available to the art, the significance of such difference, and its specific nature, including sketches, flow diagrams, etc., where necessary or helpful to a full understanding, and illustrative experimental or operational data. If this disclosure is related to prior IIDs, identify by case number or otherwise.

Objective: A device for transferring energy to fluid consisting of atleast one liquid phase and one gaseous phase. The device comprises of one or more stages are installed inside a cylindrical housing. Each stage consists of atleast one rotating part called impeller and a stationary part called diffuser. The hub and shroud surfaces of impeller and diffuser are formed by surface of revolution of one or more straight lines inclined at an angle to the axis of rotation of impellers. One or more blades confined between the hub and shroud surface are designed using Computational Fluid Dynamic Analysis to have better multiple phase handling capabilities than the conventional turbomachines designed to handle single phases. The present invention is primarily applicable to electric submersible pumping systems for producing fluids from a well bore, however can be applied to other industrial applications.

Background: Electrical Submersible Pumping (ESP) systems are used to transfer energy to the liquid and thus to produce liquids from wellbores. A typical ESP systems consists of an electric motor driving a multi-stage pumps of centrifugal or mixed flow type. These pumps have limited gas handling capabilities. When the gas volume fraction at the intake of pumps exceeds above 10-20%, they typically become gas locked.

The present invention is for a design of rotodynamic pump stages for better handling two phase fluids. The gas locking phenomenon can be explained by dynamics of the fluid flow through the impeller and diffuser. The streamwise and transverse pressure gradients, streamline curvature and slip between different phases contribute to segregation of the phases. The gas phase accumulate in certain regions of the flow passage causing head degradation and gas locking in conventional design. The current design with specific geometries, optimized with fluid dynamic analysis, minimizes the pressure gradient and curvature effects on gas handling.

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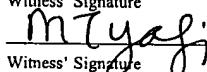
## Witnesses:

I have examined and fully understand the attached description.

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Description of the drawings:

Fig. 1 illustrates a conventional rotodynamic multi-stage pump used in electrical submersible pumping systems. The stage design, consisting of impeller and diffuser, is of high specific speed mixed flow type design.

MULTI-STAGE ELECTRICAL SUBMERSIBLE PUMP (PRIOR ART)

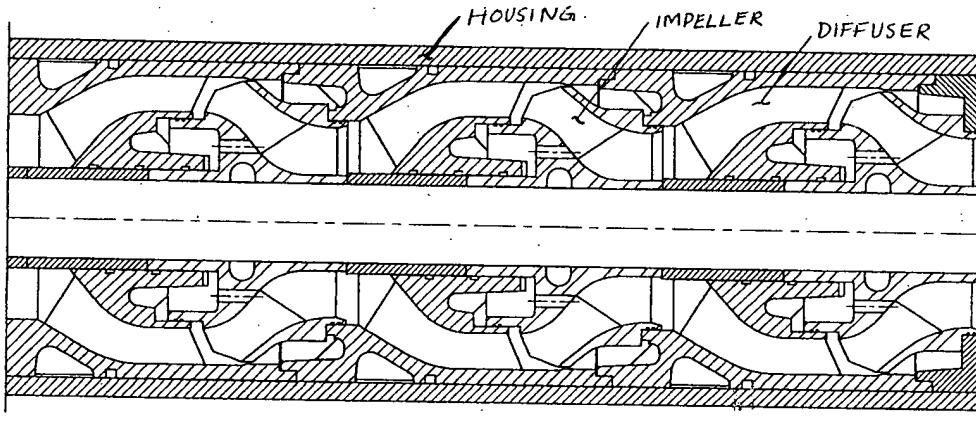


FIG. 1.

*Joe Johnson*  
Inventor's Signature

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Witnesses:

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the attached description.

*Michael Lee*  
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Inventor's Signature

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Fig. 2 illustrates a multi-stage diagonal flow turbomachine in accordance with present embodiment of the invention. The design shown in the figure is an adaptation of the present invention to the electrical submersible pump type configuration with additional innovative features. The pump consists of a series of diagonal type stages. Each stages can be of identical design or of varying design with the high capacity stages on the upstream side of the flow (generally the bottom stages in a downhole installation). The diffusers are installed in housing whose ID is honed to precise tolerances. The diffusers are prevented from rotation by keeping them under compression. The impellers rotate inside the diffuser.

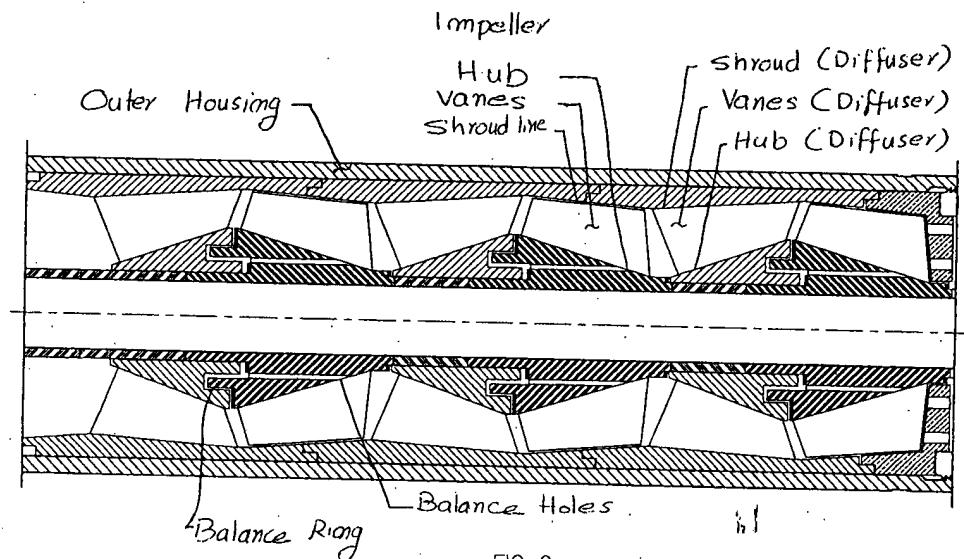


FIG. 2.

*Josephus Venkat*  
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## Witnesses:

I have examined and fully understand the attached description.

Inventor's Signature

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Date Signed

Inventor's Signature

Date Signed

*Michael Lee*  
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10-10-02  
Date Signed

Date of first disclosure to me

How Disclosed

*M. Tyagi*  
Witness' Signature

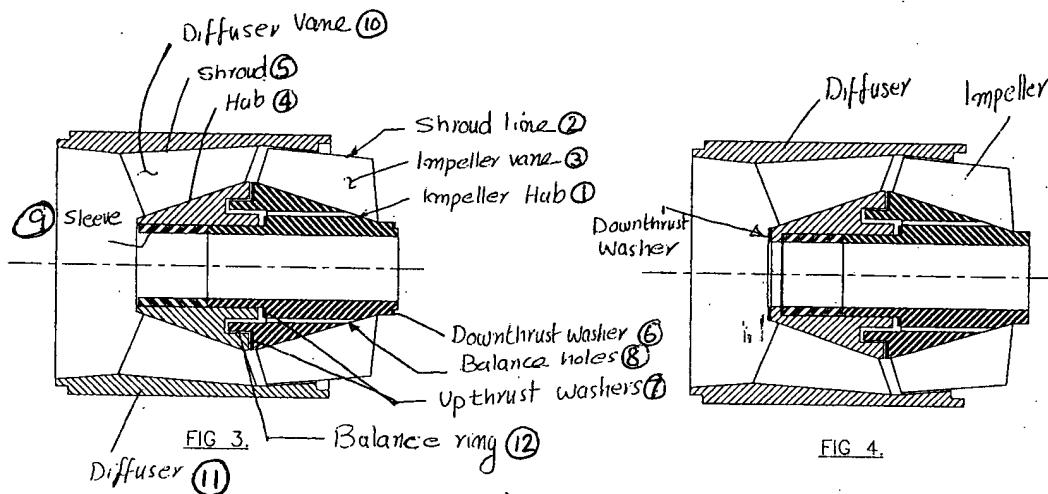
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Fig. 3 show the details of the stages which consists of atleast one impeller and diffuser. The impeller has multiple vanes (3) to transfer energy between the fluid and impeller. The impeller vanes are confined between hub (1) and shroud (2) surfaces. Each of the hub and shroud surfaces are formed by surface of revolution of atleast one line segment inclined to the axis at an angle. Each of the surface can also be formed by surfaces of revolutions of multiple line segments, preferably 2 to 5 segments, inclined at different angles to the axis. Similarly the diffuser vanes (10) are confined between hub (4) and shroud (5) surfaces, which are formed by surfaces of revolutions of multiple line segments. The upthrust washers (7), one at the hub and other at the balance ring, of the impeller restrict the impeller upward movement and downthrust washer (6) restrict the axial downward movement. Inorder to reduce the axial thrust the impeller have a balance ring (12) and balance hole(8). The hub length of the impeller, in one optional configuration, will be shorter than the axial length of the diffuser to allow for sleeve to be fixed to the shaft by a key. The sleeve made of different materials can run inside a bore machined inside the diffuser hub or run inside a bushing (not shown) pressed inside the diffuser hub. The bushing and sleeve can be of impeller material, or material of higher hardness (eg. Tungsten carbide, Silicon Carbide, Zirconia etc,) for withstanding abrasive environments or can be of peek, graphalloy etc. Fig 4. shows an alternate configuration in which downthrust washer is stationary and fixed to the diffuser hub.



*Joseph M. Venkat*  
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I have examined and fully understand the attached description.

*Michael Lee*  
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Date of first disclosure to me

How Disclosed

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Date Signed

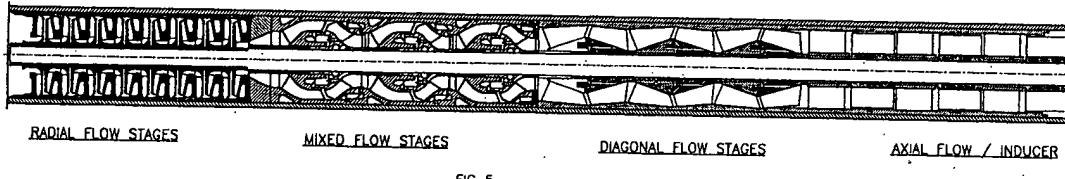
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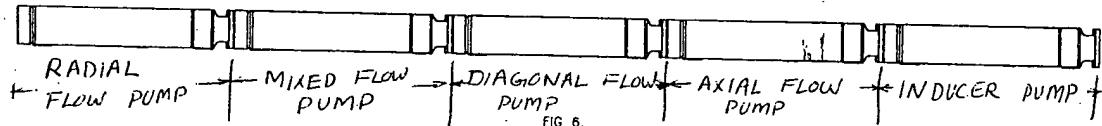
Fig. 5 show another embodiment of this invention, where a pump have stages of the present invention shown in Fig. 2, along with one or more of the following type of stages like inducers, axial flow stages, mixed flow stages and radial flow stages. The inducer and axial flow stages will be on the upstream side of the flow, followed by diagonal type stage, mixed flow stage and radial flow stages in the respective order.

Fig. 6 show an alternate embodiment of the present invention where an installation uses pumps of configuration shown in Fig 2 or Fig 5 combined with any one of the pumps like inducer, axial, mixed or radial type pump.



## MULTI-TYPE - MULTI-STAGE PUMP

FIG. 6

ELECTRICAL SUBMERSIBLE PUMPING SYSTEM WITH  
MULTI-TYPE PUMPS

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the attached description.

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Date Signed

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Date Signed

*Michael Lee*  
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10-10-02  
Date Signed

Date of first disclosure to me

How Disclosed

*M. Lee*  
Witness' Signature

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Date Signed

Date of first disclosure to me

How Disclosed

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Other Claims.

1) The details shown in the previous section are for downhole pumps, however can be applied to other type of turbomachines.

*John Venner* 10/10/2002

Inventor's Signature	Date Signed
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## Witnesses:

I have examined and fully understand the attached description.

Inventor's Signature	Date Signed
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Inventor's Signature	Date Signed
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Michael Lee	10-10-02	Date Signed	Date of first disclosure to me	How Disclosed
Witness' Signature				
<i>M. Lee</i>	10/10/02	Date Signed	Date of first disclosure to me	How Disclosed
Witness' Signature				

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